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Department of Commerce

United States Bureau of Mines
Scott Turner, Director

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MILLING METHODS OF THE AMERICAN ZINC CO. OF TENNESSEE, MASCOT, TENNESSEE

BY

C. B. Strachan

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MILLING METHODS OF THE AMERICAN ZINC CO. OF TENNESSEE, MASCOT, TENNESSEE[1]

By C. B. Strachan[2]

INTRODUCTION

The Mascot concentrator treats 1,900 tons of zinc ore per day by gravity concentration and flotation. During the year 1929 the heads averaged 2.90 per cent zinc, and the recovery was 90.15 per cent; the concentrates produced contained 60.19 per cent zinc.

ACKNOWLEDGMENT

Acknowledgment is made to M. H. Newman, geologist, Robert Ammon, chief metallurgist, D. B. Grove, mill superintendent, and W. A. Calhoun, metallurgical clerk for assistance in the preparation of this paper.

ORE TREATMENT

The ore treated in 1929 was from No. 2 mine at Mascot, and from the Jarnagin mine at Jefferson City, Tenn.

The associated minerals are a straw-colored sphalerite, dolomite, calcite, pyrite, quartz, and a small amount of greenockite, which occurs as a stain and sometimes as crystals along with sphalerite, but is somewhat rare. Pyrite is present in small quantities, usually less than 0.5 per cent of the sample. Quartz occurs in bands of a few inches thick. Complete analysis of the ore is as follows:

	Per cent
Calcium carbonate	48.11
Magnesium carbonate	35.36
Silica	8.73
Alumina	1.04
Iron oxide	1.33
Zinc sulphide	5.43
Cadmium sulphide	0
Lead sulphide	0
Total	100.00

1 The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6379."

2 One of the consulting engineers, U. S. Bureau of Mines; General Superintendent, American Zinc Co. of Tennessee.

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LOCATION

The plant is located directly on the Southern Railway, 13 miles east of Knoxville, Tenn., at Mascot, Knox County, Tenn.

HISTORY

The concentrator as originally built was a Missouri-type mill with a few more concentrating tables than are ordinarily incorporated in Joplin milling practice. The mill consisted of Cooley-type jigs, and was of 800 tons daily capacity, and started operating May 18, 1913. The heads at that time averaged 4.17 per cent zinc, and the recovery was 64 per cent. In November, 1914, the flotation plant was started, using Butte-Superior type flotation machines. The flotation plant treated approximately 20 per cent of fines from the gravity plant; the recovery in the flotation plant was 85 per cent, increasing the total recovery to approximately 75 per cent. From the year 1915 to 1922 slight increases in recovery were obtained. In the year 1922 the General Engineering Co., Salt Lake City, Utah, conducted experiments on the use of T T mixture with very gratifying results, increasing the flotation extraction from 85 to 98 per cent recovery. Later in the year T T mixture was discontinued and dry carbanilid was used instead, with better operating conditions and the same recoveries. The flow sheet in the gravity mill was then changed; the stratifying tables were eliminated, the fine grinding was increased, and all of this product was sent to the flotation plant. Since this flow sheet was adopted only minor economies have been developed.

DESCRIPTION OF CONCENTRATOR OPERATIONS

Coarse Crushing

During the year 1929, 624,759 tons of mine run ore was crushed by this plant at the rate of 98.62 tons per hour actual running time. One crude ore bin at the crushing plant (see flowsheet, fig. 1) holds 40 tons. The ore is taken from this bin as the skips dump it, by a 42-inch Stephen Adamson pan feeder traveling at the rate of 9 feet per minute and discharging into a No. 8 Chalmers and Williams Gyratory crusher. The gyratory crusher is driven by a 75-hp. motor at a speed of 147 gyrations per minute. The ore is crushed to a maximum size of 5½ inches, and is delivered to a 30-inch belt conveyor, traveling 389 feet per minute, which passes under a No. 4 S.A. suspended magnet that removes all tramp iron. The conveyor delivers the product to a stationary screen plate which is set at an angle of 45° and takes out minus 2-inch product. The oversize from this screen is crushed by a 48-inch, horizontal-shaft, Symons disk crusher to a maximum size of 2 inches. The discharge of the Symons crusher with the undersize of the stationary screen is elevated 55 feet by a 24-inch belt elevator traveling 499 feet per minute. The Symons crusher and this elevator are driven by a 100-hp. motor. The elevator dumps the crushing plant product on a 24-inch belt conveyor traveling 340 feet per minute, which delivers it into a 300-ton storage bin ready to be trammed to the concentrating mill.

The cost of crushing the ore at this plant was 2.95 cents per ton for the year 1929.

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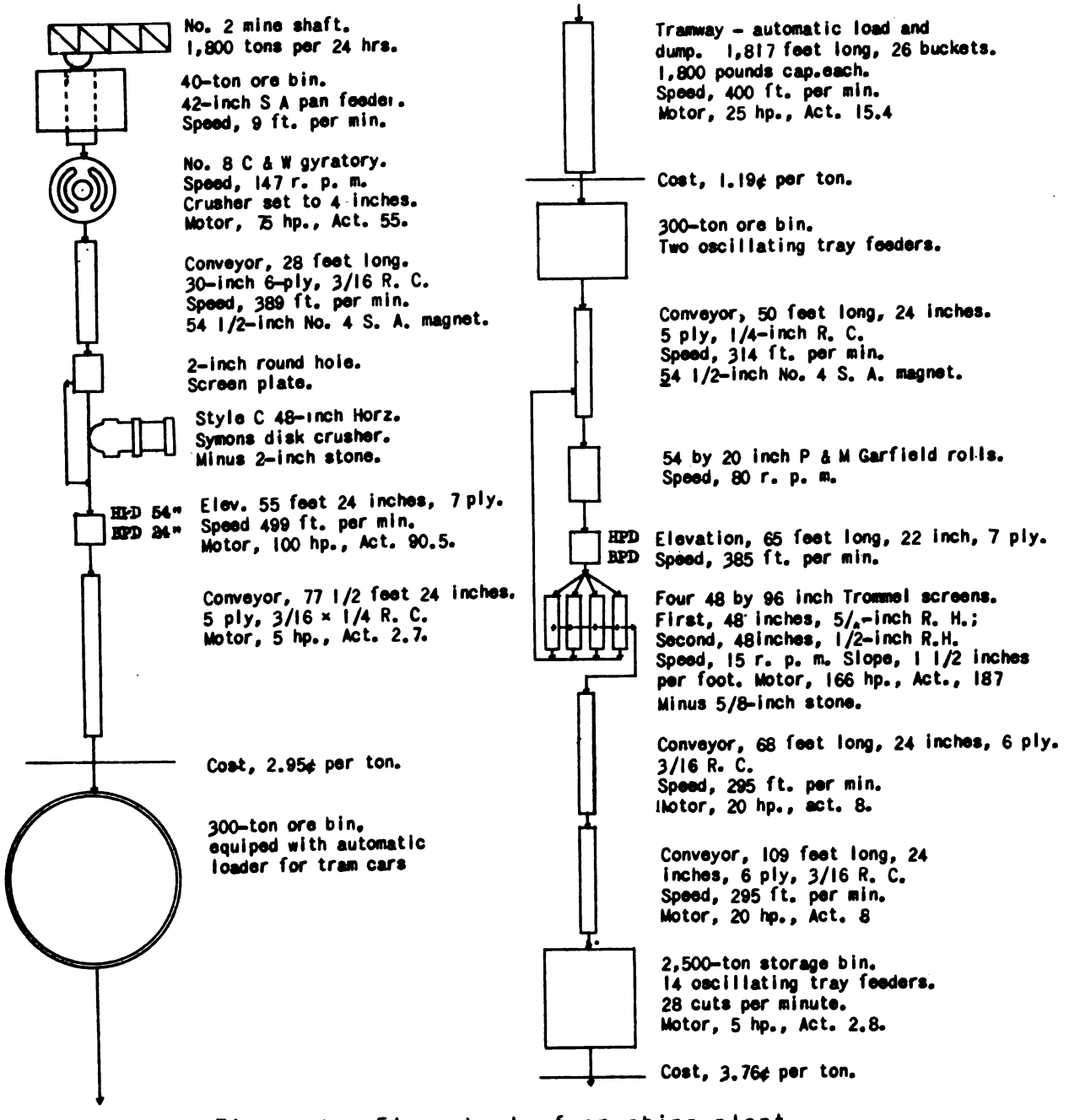
No. 2 mine shaft.
1,800 tons per 24 hrs.
40-ton ore bin.
42-inch S A pan feeder.
Speed, 9 ft. per min.
No. 8 C & W gyratory.
Speed, 147 r. p. m.
Crusher set to 4 inches.
Motor, 75 hp., Act. 55.
Conveyor, 28 feet long.
30-inch 6-ply, 3/16 R. C.
Speed, 389 ft. per min.
54 1/2-inch No. 4 S. A. magnet.
2-inch round hole.
Screen plate.
Style C 48-inch Horz.
Symons disk crusher.
Minus 2-inch stone.
HPD 54"
BPD 24"
Elev. 55 feet 24 inches, 7 ply.
Speed 499 ft. per min.
Motor, 100 hp., Act. 90.5.
Conveyor, 77 1/2 feet 24 inches.
5 ply, 3/16 × 1/4 R. C.
Motor, 5 hp., Act. 2.7.
Cost, 2.95¢ per ton.
300-ton ore bin,
equiped with automatic
loader for tram cars
Tramway - automatic load and
dump. 1,817 feet long, 26 buckets.
1,800 pounds cap.each.
Speed, 400 ft. per min.
Motor, 25 hp., Act. 15.4
Cost, 1.19¢ per ton.
300-ton ore bin.
Two oscillating tray feeders.
Conveyor, 50 feet long, 24 inches.
5 ply, 1/4-inch R. C.
Speed, 314 ft. per min.
54 1/2-inch No. 4 S. A. magnet.
54 by 20 inch P & M Garfield rolls.
Speed, 80 r. p. m.
HPD
BPD
Elevation, 65 feet long, 22 inch, 7 ply.
Speed, 385 ft. per min.
Four 48 by 96 inch Trommel screens.
First, 48 inches, 5/8-inch R. H.;
Second, 48inches, 1/2-inch R.H.
Speed, 15 r. p. m. Slope, 1 1/2 inches
per foot. Motor, 166 hp., Act., 187
Minus 5/8-inch stone.
Conveyor, 68 feet long, 24 inches, 6 ply.
3/16 R. C.
Speed, 295 ft. per min.
Motor, 20 hp., act. 8.
Conveyor, 109 feet long, 24
inches, 6 ply, 3/16 R. C.
Speed, 295 ft. per min.
Motor, 20 hp., Act. 8
2,500-ton storage bin.
14 oscillating tray feeders.
28 cuts per minute.
Motor, 5 hp., Act. 2.8.
Cost, 3.76¢ per ton.

Figure 1.- Flow sheet of crushing plant

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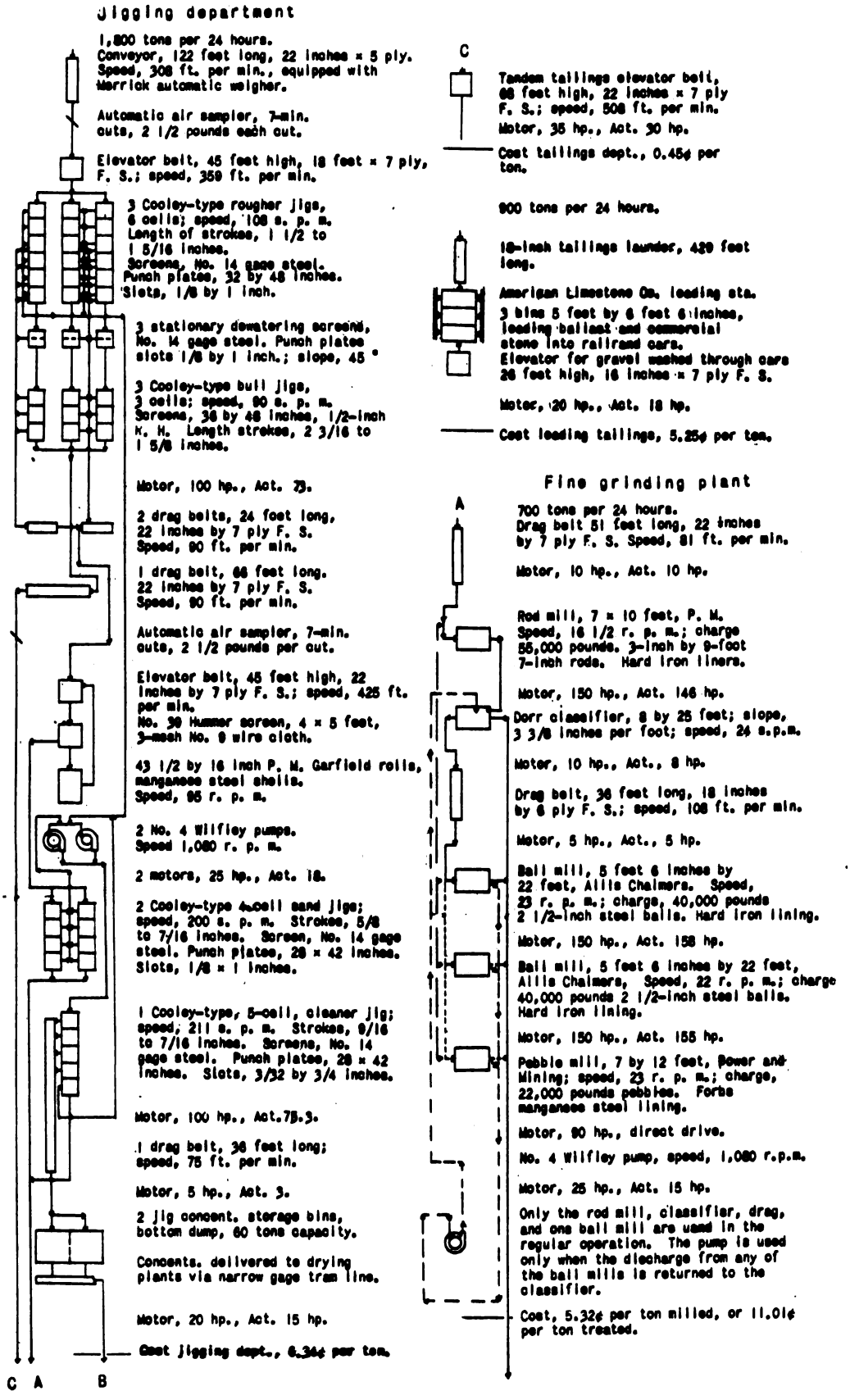
Jigging department
1,800 tons per 24 hours.
Conveyor, 122 feet long, 22 inches x 5 ply.
Speed, 308 ft. per min., equipped with Merrick automatic weigher.
Automatic air sampler, 7-min. cuts, 2 1/2 pounds each cut.
Elevator belt, 45 feet high, 18 feet x 7 ply, F. S.; speed, 359 ft. per min.
3 Cooley-type rougher jigs, 6 cells; speed, 108 s. p. m. Length of strokes, 1 1/2 to 1 5/16 inches. Screens, No. 14 gage steel. Punch plates, 32 by 48 inches. Slots, 1/8 by 1 inch.
3 stationary dewatering screens, No. 14 gage steel. Punch plates slots 1/8 by 1 inch.; slope, 45 °
3 Cooley-type bull jigs, 3 cells; speed, 90 s. p. m. Screens, 36 by 48 inches, 1/2-inch K. H. Length strokes, 2 3/16 to 1 5/8 inches.
Motor, 100 hp., Act. 73.
2 drag belts, 24 feet long, 22 inches by 7 ply F. S. Speed, 90 ft. per min.
1 drag belt, 66 feet long. 22 inches by 7 ply F. S. Speed, 90 ft. per min.
Automatic air sampler, 7-min. cuts, 2 1/2 pounds per cut.
Elevator belt, 45 feet high, 22 inches by 7 ply F. S.; speed, 425 ft. per min.
No. 30 Hummer screen, 4 x 5 feet, 3-mesh No. 9 wire cloth.
43 1/2 by 16 inch P. M. Garfield rolls, manganese steel shells. Speed, 95 r. p. m.
2 No. 4 Wilfley pumps. Speed 1,080 r. p. m.
2 motors, 25 hp., Act. 18.
2 Cooley-type 4-cell sand jigs; speed, 200 s. p. m. Strokes, 5/8 to 7/16 inches. Screen, No. 14 gage steel. Punch plates, 28 x 42 inches. Slots, 1/8 x 1 inches.
1 Cooley-type, 5-cell, cleaner jig; speed, 211 s. p. m. Strokes, 9/16 to 7/16 inches. Screens, No. 14 gage steel. Punch plates, 28 x 42 inches. Slots, 3/32 by 3/4 inches.
Motor, 100 hp., Act. 75.3.
1 drag belt, 36 feet long; speed, 75 ft. per min.
Motor, 5 hp., Act. 3.
2 jig concent. storage bins, bottom dump, 60 tons capacity.
Concents. delivered to drying plants via narrow gage tram line.
Motor, 20 hp., Act. 15 hp.
Cost jigging dept., 6.34¢ per ton.
C
Tandem tailings elevator belt, 68 feet high, 22 inches x 7 ply F. S.; speed, 508 ft. per min.
Motor, 35 hp., Act. 30 hp.
Cost tailings dept., 0.45¢ per ton.
900 tons per 24 hours.
18-inch tailings launder, 420 feet long.
American Limestone Co. loading sta.
3 bins 5 feet by 6 feet 6 inches, loading ballast and commercial stone into railroad cars.
Elevator for gravel washed through cars 26 feet high, 16 inches x 7 ply F. S.
Motor, 20 hp., Act. 18 hp.
Cost loading tailings, 5.25¢ per ton.
Fine grinding plant
A
700 tons per 24 hours.
Drag belt 51 feet long, 22 inches by 7 ply F. S. Speed, 81 ft. per min.
Motor, 10 hp., Act. 10 hp.
Rod mill, 7 x 10 feet, P. M. Speed, 16 1/2 r. p. m.; charge 55,000 pounds. 3-inch by 9-foot 7-inch rods. Hard iron liners.
Motor, 150 hp., Act. 146 hp.
Dorr classifier, 8 by 25 feet; slope, 3 3/8 inches per foot; speed, 24 s.p.m.
Motor, 10 hp., Act., 8 hp.
Drag belt, 36 feet long, 18 inches by 6 ply F. S.; speed, 108 ft. per min.
Motor, 5 hp., Act., 5 hp.
Ball mill, 5 feet 6 inches by 22 feet, Allis Chalmers. Speed, 23 r. p. m.; charge, 40,000 pounds 2 1/2-inch steel balls. Hard iron lining.
Motor, 150 hp., Act. 158 hp.
Ball mill, 5 feet 6 inches by 22 feet, Allis Chalmers, Speed, 22 r. p. m.; charge 40,000 pounds 2 1/2-inch steel balls. Hard iron lining.
Motor, 150 hp., Act. 155 hp.
Pebble mill, 7 by 12 feet, Bower and Mining; speed, 23 r. p. m.; charge, 22,000 pounds pebbles. Forbs manganese steel lining.
Motor, 90 hp., direct drive.
No. 4 Wilfley pump, speed, 1,080 r.p.m.
Motor, 25 hp., Act. 15 hp.
Only the rod mill, classifier, drag, and one ball mill are used in the regular operation. The pump is used only when the discharge from any of the ball mills is returned to the classifier.
Cost, 5.32¢ per ton milled, or 11.01¢ per ton treated.
C A B

Figure 2.- Flow sheets of jigging department and fine grinding plant

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Tramming

The ore is drawn out of the 300-ton storage bin by an automatic air-controlled gate and balanced loading capsule.

The tram line is 1,817 feet long and has 26 buckets of 1,800 pounds capacity each. It is driven by a 25-hp. motor at a speed of 400 feet per minute.

The cost of tramming ore over this line was 1.19 cents per ton for the year 1929.

Fine Crushing Plant

The product of the coarse crushing plant is stored in a 300-ton bin. Two pan feeders deliver the ore to a 24-inch belt conveyor which travels 314 feet per minute, passing under a suspended 54½-inch type No. 4 S.A. magnet and into a set of 54 by 20 inch Power & Mining Garfield rolls, making 80 revolutions per minute. The crushing rate of the rolls for the year 1929 was 103.10 tons per hour, running time. After the ore goes through the rolls it is elevated 65 feet by a 22-inch belt elevator traveling 385 feet per minute, and is delivered to four 48 by 96 inch Trommel screens which revolve 15 times per minute. The first 48 inches of the screens have 5/8-inch round hole openings and the last 48 inches have ½-inch round hole openings. The oversize from these screens is returned by means of a chute to the 24-inch conveyor which feeds the rolls.

The 24-inch conveyor, rolls, elevator, and Trommel screens are driven by a 166-hp. motor.

The minus 5/8-inch product is delivered to a 24-inch belt conveyor which travels 327 feet per minute, and is driven by a 20-hp. motor. From this point the ore is delivered by another 24-inch belt conveyor, traveling at a speed of 295 feet per minute, to a 2,500-ton storage bin.

This belt is driven by a 20-hp. motor. The ore is then ready to be treated by jig mill.

The cost of crushing the minus 2-inch ore to a minus 5/8-inch product was 3.76 cents per ton for the year 1929.

Jigging Department

The ore is drawn from the 2,500-ton storage bin at the rate of 75 tons per hour, or 1,800 tons per 24 hours, (see flowsheet, fig. 2) by 14 oscillating tray feeders, driven by a 5-hp. motor at a speed of 28 cuts per minute, and is delivered by a 20-inch belt conveyor, traveling 308 feet per minute over a Merrick weightometer, which weighs the ore automatically. At the discharge of the conveyor an automatic sampler takes a 2½-pound sample every seven minutes, which is crushed by a style B, Allis-Chalmers sample grinder. This sample is rolled and cut down to about 50 pounds at the end of every 8-hour shift, and there prepared for assaying.

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The ore dumps by gravity into a pit where sufficient water is added, and is then elevated 45 feet by an 18-inch belt elevator, traveling 359 feet per minute.

The product is then split into three equal parts and is delivered by means of launders to three 6-cell, Cooley-type, rougher jigs. The screens, or punch plates on these jigs, are made from 14-gage high-carbon steel, 32 inches by 48 inches, with slots 1/8 by 1 inch. The strokes are as follows: Cells No. 1 and 2, 1½ inches; 3 and 4, 1 3/8 inches; 5 and 6, 1 5/16 inches. Speed, 108 strokes per minute.

The product that goes through the punch plates, or fine middling, is delivered to the pump sump. It is then pumped to cleaner jigs.

The cleaner and sand jig tailings dump into a drag belt pit, the overflow of which goes to a Dorr thickener tank. It is then delivered by a 22-inch drag belt to the fine grinding plant. This belt travels 81 feet per minute and is driven by a 10-hp. motor.

Fine Grinding Plant

In this plant we have one 7 by 10 foot rod mill, Power & Mining, driven by a 150-hp. motor (see flowsheet, fig. 2); one 8 by 25 foot Dorr classifier driven by a 5-hp motor; one 18-inch drag belt driven by a 5-hp. motor at 108 feet per minute; two 5-foot 6-inch by 22-foot Allis-Chalmers ball mills driven by a 150-hp. motor each; one 7 by 12 foot pebble mill, Power & Mining, driven by a 90-hp. motor; and also a No. 4 Wilfley pump driven by a 25-hp. motor at 1,080 revolutions per minute

Only the rod mill, one ball mill, a Dorr classifier, and a drag belt are employed in the regular operation of this plant.

Description of operation.- The total feed going to the fine grinding plant is fed into the rod mill; the discharge of the rod mill passes into the Dorr classifier, and the overflow of the classifier goes direct to the flotation plant via the slime pump.

The rake returns from the Dorr thickener tank, and the discharge of the drag is fed into the ball mill, the discharge of which goes to the flotation plant via the slime pump.

The cost in this department was 11.01 cents per ton treated, or 5.32 cents per ton milled for the year 1929.

The coarse middlings product drawn off from cells No. 3, 4, 5, and 6, goes to two drag belts. The rougher jig tailings are dewatered over a 1/8 by 1 inch slot punch plate set at an angle of 45°, the undersize going into the coarse middlings circuit, the oversize being fed to three 3-cell, Cooley-type, bull jigs. Screen size, 36 by 48 inches, ½-inch round hole. Length of stroke, 2 3/16 inches for the first cell, 1 7/8 inches for the second cell, 1 5/8 inches for the third cell. Speed, 90 strokes per minute.

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The conveyor, elevator, rougher, and bull jigs are operated by a 100-hp. motor.

The tailings from the three bull jigs, amounting to about 50 per cent of the tonnage milled and which would be 900 tons per 24 hours, goes direct to a 22-inch drag belt that travels 90 feet per minute. The overflow from this drag goes to Dorr thickener tanks. Every 7 minutes a 2½-pound sample is cut from the discharge by an automatic sampler. This sample is collected at the end of each 8-hour shift and is prepared for assaying.

The tailings are then elevated 68 feet by a 22-inch belt elevator, traveling 508 feet per minute. This elevator is driven by a 35-hp. motor. The cost in this department is 0.45 cents per ton milled. The product is then delivered 429 feet by a launder to the American Limestone Co. to be loaded into railroad cars for shipment. The cost in this department is 5.25 cents per ton loaded.

The product that passes through the bull jig screens goes into the coarse middlings launder with the coarse middlings from the rougher jigs and dewatering screens, and is delivered to two 24-inch drag belts. The overflow from both drags goes to Dorr thickener tanks. They discharge into a pit from which it is elevated 45 feet by a 22-inch belt elevator traveling 425 feet per minute.

This elevator closes the circuit between a No. 39 Hummer screen, on which is used a 4 by 5 foot, 3-mesh, No. 9 wire cloth, and a set of 43½ by 16 inch Power & Mining Garfield rolls. The manganese steel shells make 95 revolutions per minute. The minus-3-mesh product is fed to two four-cell Cooley-type sand jigs. The stroke on the first cell is 5/8 inch; second and third cells, ¾ inch; and fourth cell, 7/16 inch. The speed of strokes is 200 per minute. The screen, or punch plate, is No. 14 gage high carbon steel, 28 by 42 inches, slots 1/8 by 1 inch.

The product that goes through the punch plates is delivered by a launder to the same pump sump as the fine middlings from rougher jigs, and is pumped to the feed end of a five-cell Cooley-type cleaner jig by two No. 4 Wilfley pumps driven by two 25-hp. motors at 1,080 revolutions per minute. The punch plates used on this jig are No. 14 gage high carbon steel, 28 by 42 inch, slots 3/32 by 3/4 inches. The speed is 211 strokes per minute. The length of the stroke on the first cell is 9/16 inch; on the second, 9/16 inch; the third, 1/2 inch; the fourth, 1/2 inch; and the fifth, 7/16 inch.

The product of the first four cells is jig concentrates, and will average about 30 tons per 24 hours. This is delivered to two storage bins of 60 tons capacity each by a 12-inch drag belt traveling 75 feet per minute and driven by a 5-hp. motor. The fifth cell product is returned to the middlings pump and back to the heads end of the cleaner with new feed.

The rolls, middlings elevator, the two middlings drags, the tailings drag, the two sand jigs, and the cleaner jigs are all driven by one 100-hp. motor.

The jigging department cost was 6.34 cents per ton treated for the year 1929.

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Water Supply

The fresh water supply is taken from Flat Creek; it is delivered from the dam by means of a race to a 13½ by 18 inch Prescott horizontal double acting plunger pump driven by a 100-hp. motor and with a capacity of 1,700 gallons per minute. The water used in the mill is taken from a stand pipe in order to obtain a uniform pressure at all times (fig. 3).

The overflow water from the six Dorr tanks is returned to the mill by two pumps, one a 13 by 24 inch Prescott horizontal duplex, double-acting, Mesaba-type plunger pump; driven by a 100-hp. motor, and with a capacity of 2,500 gallons per minute; the other pump is a 14 by 14 inch vertical Gould plunger pump, driven by a 35-hp. motor, and with a capacity of 1,000 gallons per minute.

The overflow from all the drag belts in the mill is fed into six Dorr thickener tanks, four 30-foot, one 36-foot, and one 50-foot. These tanks are driven by one 5-hp. motor and one 7½-hp. motor. The plows make one revolution every three minutes.

The overflow water from these Dorr tanks goes to the return pumps and back to the mill to be used again, as defined above.

The water supply cost was 3.06 cents per ton milled for 1929.

Pumping Flotation Slimes

The dilution of the Dorr tank spigot is four parts water to one of solids. This product, which amounts to about 170 tons per 24 hours, along with the fine grinding plant product is pumped to the flotation plant by a No. 4 Wilfley pump, driven by a 75-hp. motor at 1,200 revolutions per minute.

The cost of pumping this slime to the flotation plant was 0.44 cents per ton milled for the year 1929.

Flotation Plant

The flotation slime is sampled every 8 minutes as it enters the plant by a Galigher mechanical sampler, driven by a ¼-hp. motor. This sample is taken up and prepared for assaying at the end of each 8-hour shift (fig. 3-B).

The slime is then divided into four equal parts, one of which is fed into each of the four 30 by 10 foot Dorr thickener tanks. The plows in these tanks make one revolution in 3 minutes and 45 seconds. The overflow from tanks goes to waste. These four Dorr tanks, the middlings tank, and the reagent feeders are driven by two 5-hp. motors and one 3-hp. motor.

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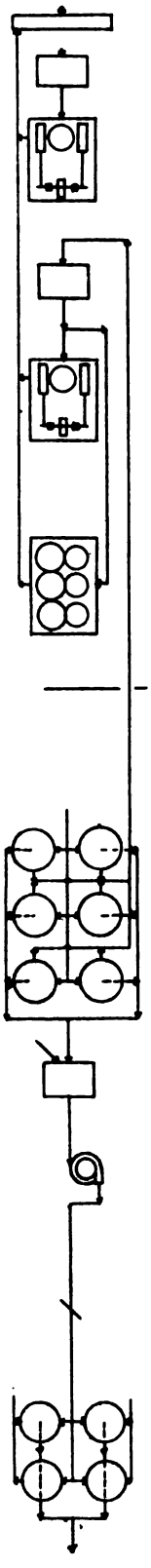

Mill water supply, stand pipe.

Concrete sump with screen; water supply from mill race.

13 1/2 by 18 inch Prescott horizontal double-acting plunger pump. Cap., 1,700 g. p. m.

Motor, 100 hp., Act. 99

Concrete sump with screen, overflow to creek pump, water supply from mill Dorr tanks, and return water from mill stand pipe.

13 by 24 inch Prescott horizontal duplex double-acting Mesabi-type plunger pump. Cap., 2,500 g.p.m.

Motor, 100 hp., Act. 75.

14 x 14 inch vertical Gould plunger pump. Cap, 1000 g. p. m. Delivers water to jig tailings, elevator, and launder.

Motor, 35 hp., Act. 30.

Cost, 3.06¢ per ton milled.

Feed to Dorr tanks, overflow from mill drag belts.

Four 30-foot Dorr tanks.
One 36-foot Dorr tank.
One 50-foot Dorr tank.
Speed of plows, one revolution every 3 minutes.
Spigot discharge dilution, W/S 4 to 1
One 5-hp. motor, Act. 2.
One 7 1/2-hp. motor, Act. 7.

Concrete sump with screen.
Feed - fine grinding plant discharge and Dorr tank spigot discharge.

No. 4 Wilfley pump; speed, 1,200 r. p. m.
Motor, 75 hp., Act. 33.5.

Cost, 0.44¢ per ton milled.

B

Gaigher mechanical sampler, cuts samplee every 8 minutes.
Motor, 1/4 hp.

Four 30 by 10 foot Dorr tank thickeners. Speed, 1 revolution in 3 minutes 45 seconds. Dilution spigot discharge 1 to 1. Overflow to waste.
Two motors, 5 hp., Act. 4.
One motor, 3 hp., Act. 3.

B

870 tons per 24 hours.
Reagents: Thiocarbanilide, pine oil No. 5, Barrett oil No. 634, and copper sulphate.

Mixing tank, with 3 Janney-type agitators. Speed, 570 r. p. m.

Three motors, 10 hp., Act. 9.

Two double spitz altered Janney rougher cells. Speed, 570 r.p.m. Spitz overflow to cleaner cells; Tails to middlings cells.

Two motors, 10 hp., Act. 12.

Six single spitz altered Janney middlings cells. Speed, 570r.p.m. 22-inch difference in elevation between cells. Spitz overflow to middlings pump. Tailings to American Limestone Co.

Six motors, 10 hp., Act. 11.

Two single spitz altered Janney cleaner cells. Speed, 570 r.p.m. Spitz overflow finished concentrates to concentrates pump. Tailings to middlings pump.

Two motors, 10 hp., Act. 9.

20 x 10 foot circular tank for middlings; no overflow.

No. 4 Wilfley pump. Speed, 1,200 r.p.m.
Motor, 20 hp., Act. 15.

Gaigher mechanical sampler. Cuts sample every 8 minutes.

Motor, 1/4 hp.

No. 4 Wilfley pump. Speed, 1,200 r.p.m. Discharge to American Limestone Co.

Motor, 25 hp., Act. 24.8.

Gaigher mechanical sampler. Cuts every 8 minutes.

Motor, 1/4 hp.

No. 2 Wilfley pump, speed, 1,400 r. p. m.
Motor, 10 hp., Act. 7.

Cost, 15.91¢ per ton treated or 7.73¢ per ton milled.

Figure 3.- A, Flow sheet of water supply and thickener department; B, flow sheet of flotation plant

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The dilution of the Dorr tank spigot is kept at one to one. This product, which will average 870 tons per 24 hours, is first fed into the mixer tank where the reagents, thiocarbanilide, pine oil No. 5, Barrett oil No. 634, and copper sulphate are mixed with the thick pulp by two Janney-type agitators. The middlings returns are fed into this tank and are mixed with the new feed by a third Janney-type agitator. The agitators of all three machines are driven at 570 revolutions per minute by three 10-hp. motors. The total reagent consumption amounts to 7.4 cents per ton of slimes treated.

The product from the mixer tank is then fed into the rougher units. These units consist of two double spitz altered Janney cells. The agitators of both cells are driven by a 10-hp. motor each, at a speed of 570 revolutions per minute. The spitz overflow, or rougher concentrates, is delivered to two cleaner cells, which will be defined later.

The tailings from the rougher unit are further treated by six single spitz altered Janney middling cells, each cell 22 inches below the preceding one; the tailings from first unit form the feed to the next, down to the last unit, which makes the final tailings.

This product is sampled by a Galigher mechanical sampler driven by a $\frac{1}{4}$-hp. motor, cutting a sample every 8 minutes. This sample is taken up at the end of each 8-hour shift and prepared for assaying. The tailings are then pumped to the American Limestone Co. by a No. 4 Wilfley pump, driven by a 25-hp. motor at a speed of 1,200 revolutions per minute.

The spitz overflow of the rougher machines; or the rougher concentrates, is cleaned by two single spitz altered Janney cells, the agitators on both cells driven by a 10-hp. motor each, at a speed of 570 revolutions per minute. The spitz overflow of these two cells is finished concentrates. It is sampled by a Galigher mechanical sampler, driven by a $\frac{1}{4}$-hp. motor, cutting a sample every 8 minutes. This sample is collected at the end of each 8-hour shift and prepared for assaying. The concentrates are then pumped to the drying plant by a No. 2 Wilfley pump, driven by a 10-hp. motor at 1,400 revolutions per minute.

The tailings from the cleaner unit, with the spitz overflow of the six middling units, go to a No. 4 Wilfley pump, driven by a 20-hp. motor at 1,200 revolutions per minute, and are pumped to a 20 by 10 foot circular middlings tank. The middlings are returned to the mixer tank, as was explained above, by a 6-inch pipe line equipped with a stop cock so that the flow can be regulated.

The cost in this department was 15.91 cents per ton treated, or 7.73 cents per ton milled.

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Drying Plant

The flotation concentrates are received by a 25-foot Dorr thickener tank. The overflow water is taken off 5 feet from the top of the tank and is allowed to run through a series of small settling boxes. These boxes are cleaned out every three weeks, thus reclaiming some concentrates which would otherwise go to waste (fig. 4).

The concentrates are drawn out of the Dorr tank by a No. 4 Dorrco suction pump. This pump makes 31½ strokes per minute. A 5-hp. motor drives the Dorr tank and pump.

The discharge of the Dorrco pump will average 37.00 per cent H_2O. This product is then filtered by a 5-foot 4-inch by 8-foot Oliver continuous filter, making one revolution every 5½ minutes. The filter cake will average 7.5 per cent H_2O. The filtrate is delivered by a 2-inch centrifugal pump to the same settling boxes that the Dorr tank overflow is settled in. This pump is driven by a 5-hp. motor.

The vacuum is maintained at 22.7 inches vacuum by an Oliver-type M.O., 14 by 8 inch vacuum pump. The filter and vacuum pump are driven by a 25-hp. motor.

Nut and slack coal is received in carload lots, dumped into a hopper, and elevated 43½ feet by a No. 823 L.B. chain, with steel buckets M.S.10 by 6A, traveling 124 feet per minute to a storage bin of 60 tons capacity. The coal is then delivered by a wheelbarrow to hopper which holds an 8-hour run. The coal is drawn from this hopper to a Biggs Under Feed stoker, operated by an automatic air cylinder. The air draft is furnished by a No. 6 fan, driven at 1,147 revolutions per minute by a 5-hp. motor.

The heat from this furnace goes directly to a 12 by 32 foot Lowden dryer.

The filtered flotation concentrates from the filter drop directly on the head end of the Lowden dryer. The crushed jig concentrates are fed on the head end of the dryer from a bin by a pan tray feeder.

The mixed concentrates will assay 6.50 per cent H_2O. This product is dragged over the dryer plates very slowly by rakes which make two and a third 10-inch strokes per minute. The discharge of the dryer will average .10 per cent H_2O. This product is then delivered by two 12-inch screw conveyors to an elevator. The dryer and the two screw conveyors are driven by a 5-hp. motor. It is then elevated 46 feet 2 inches by a No. 823 L.B. chain with steel buckets 8 by 5A, traveling 252 feet per minute, and is conveyed by a 12-inch screw conveyor to the center of storage tank. Elevator and conveyor are driven by a 10-hp. motor.

The storage bin is a 20 by 20 foot circular, hopper-bottomed, steel tank of 300 tons capacity. The concentrates are delivered to a box car loader by a 12-inch screw conveyor, driven by a 5-hp. motor. The box car loader is also driven by a 5-hp. motor.

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The jig concentrates are trammed by gravity from the mill storage bins by a 2.5 ton capacity car to the drying plant, the empty car being pulled back by a hoist driven by a 20-hp. motor. The concentrates are then elevated 32 feet by an 18-inch belt elevator, traveling 270 feet per minute, and are fed into a 4 by 8 foot by 1/8 inch round hole Trommel screen. The undersize product is conveyed by a 12-inch screw conveyor to a jig concentrates storage bin of 75 tons capacity which is equipped with pan feeder to feed this product on the head end of the Lowden dryer.

The oversize product from screen is fed into a set of 12 by 24 inch Chalmers and Williams rolls. The speed of the rolls is 80 revolutions per minute. The crushed product is returned to Trommel screen by the elevator with the new feed. This equipment is driven by a 25-hp. motor.

The cost in this department was 2.88 cents per ton milled, or 65.63 cents per ton of concentrates treated for year 1929.

Table 1.--Screen sizes of coarse crushing plant products

Screen size	Gyratory discharge[1]		Symons discharge	
	Weight, per cent	Cum. weight, per cent	Weight, per cent	Cum. weight, per cent
On 5 inch	7.9	7.9	- -	- -
On 4½ inch	6.1	14.0	- -	- -
On 4 inch	9.4	23.4	- -	- -
On 3½ inch	12.7	36.1	- -	- -
On 3 inch	9.0	45.1	- -	- -
On 2½ inch	10.4	55.5	- -	- -
On 2 inch	10.0	65.5	- -	- -
On 1¾ inch	4.5	70.0	17.9	17.9
On 1½ inch	3.5	73.5	10.9	28.8
On 1¼ inch	3.9	77.4	16.4	45.2
On 1 inch	4.6	82.0	12.7	57.9
On ½ inch	7.4	89.4	19.8	77.7
On 9.423 M.M.	0.9	90.3	2.7	80.4
On 3-mesh	2.4	92.7	4.5	84.9
On 6-mesh	2.8	95.5	5.2	90.1
Through 6-mesh	4.5	100.0	9.9	100.0
Totals	100.0	100.0	100.0	100.0

1 Gyratory discharge is Symons feed.

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Table 2.--Mill feed

Solids			Zinc				Iron			
Screen size	Weight, %	Cum. weight, %	Assay, % Zn.	Cum. assay, % Zn.	Total Zn., %	Cum. % total Zn.	Assay, % Fe.	Cum. assay, % Fe.	Total Fe., %	Cum. % total Fe.
3	30.5	30.5	1.95	1.95	18.4	18.4	.67	.67	30.7	30.7
6	28.9	59.4	2.55	2.24	22.9	41.3	.75	.71	32.6	63.3
10	11.1	70.5	3.42	2.43	11.8	53.1	.70	.71	11.6	74.9
20	9.2	79.7	4.35	2.65	12.4	65.5	.62	.70	8.6	83.5
35	5.6	85.3	5.50	2.84	9.5	75.0	.57	.69	4.8	88.3
65	4.2	89.5	5.85	2.98	7.6	82.6	.57	.68	3.6	91.9
100	2.3	91.8	5.90	3.05	4.2	86.8	.55	.68	1.9	93.8
150	1.1	92.9	5.90	3.08	2.0	88.8	.55	.68	.9	94.7
200	1.5	94.4	5.65	3.13	2.6	91.4	.47	.67	1.1	95.8
-200	5.6	100.0	4.95	3.23	8.6	100.0	.50	.67	4.2	100.0
TOTAL	100.0	100.0	3.23	3.23	100.0	100.0	.67	.67	100.0	100.0

Table 3.--Total jig tails

Screen size	Solids	
	Weight, per cent	Cum. weight, per cent
On 5/8-inch round hole	0.0	0.0
On 1/2-inch round hole	9.3	9.3
On 3/8-inch round hole	30.1	39.4
On 1/4-inch round hole	26.3	65.7
On 10-inch mesh	31.9	97.6
Through 10-inch mesh	2.4	100.0
Total	100.0	100.0

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Table 4.--Jig concentrates

Screen size	Solids		Zinc				Iron				Lime			
	Weight, %	Cum. weight, %	Assay, % Zn.	Cum. assay, % Zn.	Total Zn., %	Cum. % total Zn.	Assay, % Fe.	Cum. Fe., %	Total Fe., %	Cum. % total Fe.	Assay, % CaO.	Cum. CaO, %	Total CaO, %	Cum. % total CaO.
6	8.7	8.7	56.00	56.00	8.2	8.2	2.90	2.90	10.8	10.8	3.35	3.35	14.0	14.0
10	42.4	51.1	58.00	57.66	41.7	49.9	2.40	2.49	43.7	54.5	2.65	2.77	53.8	67.8
20	34.1	85.2	61.40	59.16	35.4	85.3	1.80	2.21	26.3	80.8	1.10	2.10	18.0	85.8
35	10.9	96.1	61.40	59.30	11.1	96.4	2.50	2.24	11.7	92.5	1.50	2.03	7.7	93.5
65	2.8	98.9	54.80	59.17	2.6	99.0	4.40	2.30	5.3	97.8	3.10	2.06	4.2	97.7
-65	1.1	100.0	51.20	59.08	1.0	100.0	4.70	2.33	2.2	100.0	4.40	2.09	2.3	100.0
Total	100.0	100.0	59.08	59.08	100.0	100.0	2.33	2.33	100.0	100.0	2.09	2.09	100.0	100.0

Table 5.--Flotation feed

Screen size	Solids		Zinc				Iron			
	Weight, %	Cum. weight, %	Assay, % Zn	Cum. assay, % Zn.	Total Zn., %	Cum. % tot. Zn.	Assay, % Fe.	Cum. assay, % Fe.	Total Fe., %	Cum. % tot. Fe.
35	1.7	1.7	2.00	2.00	1.0	1.0	.70	.70	2.5	2.5
65	11.7	13.4	2.85	2.74	9.6	10.6	.52	.54	12.7	15.2
100	14.4	27.8	3.00	2.88	12.5	23.1	.45	.49	13.5	28.7
150	10.0	37.8	3.55	3.05	10.3	33.4	.42	.47	8.7	37.4
200	13.4	51.2	3.90	3.28	15.1	48.5	.42	.46	11.7	49.1
-200	48.8	100.0	3.65	3.46	51.5	100.0	.50	.48	50.9	100.0
Total	100.0	100.0	3.46	3.46	100.0	100.0	.48	.48	100.0	100.0

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Table.6.--Flotation tails

Screen size	Solids		Zinc				Iron			
	Weight, %	Cum. weight, %	Assay, % Zn.	Cum. zinc, %	Total Zn., %	Cum. % tot. Zn.	Assay, % Fe.	Cum. Fe., %	Total Fe., %	Cum. % tot. Fe.
65	14.4	14.4	.15	.15	24.4	24.4	.57	.57	18.1	18.1
100	15.2	29.6	.09	.12	15.5	39.9	.45	.51	15.1	33.2
150	11.7	41.3	.07	.10	9.3	49.2	.40	.47	10.3	43.5
200	9.8	51.1	.06	.09	6.6	55.8	.37	.46	8.0	51.5
-200	48.9	100.0	.08	.09	44.2	100.0	.45	.45	48.5	100.0
Totals	100.0	100.0	.09	.09	100.0	100.0	.45	.45	100.0	100.0

Table 7.--Flotation concentrates

Screen size	Solids		Zinc				Iron				Lime			
	Weight, %	Cum. weight, %	Assay, % Zn.	Cum. Zn., %	Total Zinc, %	Cum. % tot. Zn	Assay, % Fe.	Cum. Fe., %	Total Fe., %	Cum. % tot. Fe.	Assay, % CaO	Cum. CaO, %	Total CaO, %	Cum. % total CaO
65	5.3	5.3	60.80	60.80	5.2	5.2	.40	.40	1.5	1.5	2.40	2.40	9.0	9.0
100	13.8	19.1	59.60	59.93	13.4	18.6	.70	.62	6.7	8.2	2.85	2.73	28.0	37.0
150	11.5	30.6	60.80	60.26	11.4	30.0	1.20	.84	9.6	17.8	1.90	2.41	15.6	52.6
200	13.6	44.2	62.20	60.85	13.8	43.8	1.30	.98	12.3	30.1	1.20	2.04	11.6	64.2
-200	55.8	100.0	62.00	61.50	56.2	100.0	1.80	1.44	69.9	100.0	.90	1.40	35.8	100.0
Total	100.0	100.0	61.50	61.50	100.0	100.0	1.44	1.44	100.0	100.0	1.40	1.40	100.0	100.0

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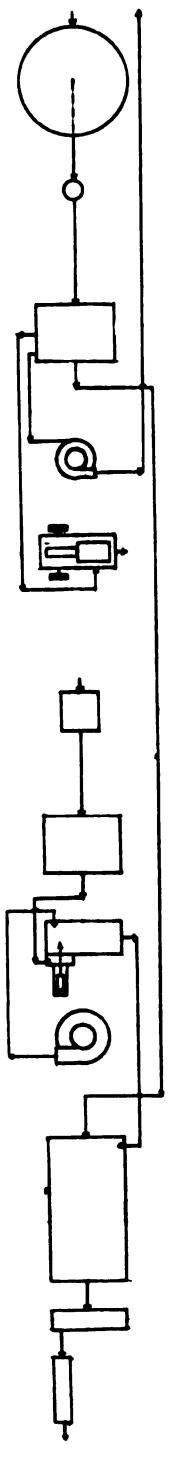

60 tons per 24 hours.
25 by 20 foot Dorr tank.

Speed, 1 revolution in 1 minute and 52 seconds. Overflow taken off 5 feet from top of tank and sent to waste.

No. 4 Dorrco suction pump.
Speed, 31 1/2 s. p. m.

Motor, 5 hp., Act. 2.9.

5 feet 4 inches by 8 feet Oliver continuous filter. Type 6 S. S. 40 B. B. No. 13073. Speed, 1 revolution in 5 3/4 minutes.
Type cloth No. 3 O.
2-inch centrifugal filter pump.
Motor for filter pump only.
5 hp., Act. 2.9.

Vacuum pump. Type Oliver M. O. No. 872. Size, 14 by 8 inches.

Motor, 25 hp., Act. 9.7.

Coal elevator, L. B. chain No. 823, 43 1/2 feet high. Steel buckets M. S. 10 X 6A. spaced every fourth link.
Speed, 124 ft. per min.

Coal bin. Capacity 60 tons. Coal is delivered in wheelbarrows from this bin to feed hopper of stoker.

Biggs under feed coal stoker. Operated by automatic air cylinder.

Stoker air draft - No. 6 fan - Buffalo Forge Co. Speed, 1,147 r.p.m.

Motor, 5 hp., Act. 1. 6.

12 by 32 foot Lowden dryer.
Speed, 2 1/3 s. p. m. Feed to dryer assays about 6.50 per cent of H_2O. The discharge assays 9.10 per cent of H_2O.

12-inch by 12-foot screw conveyor.

12-inch by 16-foot screw conveyor. Delivers dried concentrates to storage bin elevator.

Motor, 5 hp., Act. 4.6.

Elevator, 46 feet 2 inches high. Chain L. B. No. 823 with K_2 attachments every fourth link. Steel buckets, 8 by 5A. Speed, 252 ft. per min.

Motor, 10 hp., Act. 4.8.

12-inch by 10-foot 10-inch screw conveyor.

20 by 20 foot circular steel storage tank. Capacity, 300 tons. Hc Hopper bottom.

12-inch by 20-foot screw conveyor. Delivers concentrates to box car loader.

Motor, 5 hp., Act. 4.3.

Screw box car loader.

Motor, 5 hp., Act. 3.

Jig concentrates, 30 tons per 24 hours. Elevator, 32 feet high, 18 inches by 6 ply F. S. Speed, 270 ft. per min.

4 by 8 foot Trommel screen, 1/8-inch round hole. Slope, 2 inches per foot
Speed, 17 r. p. m.

12-inch by 20-foot screw conveyor. Delivers crushed jig concentrates to jig concentrates bin over Lowden dryer.

12 by 24 inch C. & W. rolls.
Speed, 80 r. p. m.
Tire steel shells.

Motor, 25 hp., Act 11.

75-ton jig concentrates bin over dryer. Bottom dump, pan tray feeder. Feeds crushed jig concentrates on head end of dryer.

Cost, 2.88¢ per ton milled or 65.63¢ per ton treated.

Figure 4.- Flow sheet of filtering and drying department

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